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Aspnes

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(54) **NORMAL INCIDENCE ROTATING COMPENSATOR ELLIPSOMETER**

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(58) **Field of Classification Search** ..... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,739,909	A	4/1998	Blayo et al.	356/369
5,798,837	A	8/1998	Aspnes et al.	356/369
5,872,630	A	2/1999	Johs et al.	356/369
5,910,842	A	6/1999	Piwonka-Corle et al.	356/369
6,429,943	B1	8/2002	Opsal et al.	356/625
6,449,043	B2	9/2002	Aspnes et al.	356/369
6,456,376	B1	9/2002	Liphardt et al.	356/369
6,583,875	B1	6/2003	Wei et al.	356/369
6,665,070	B1	12/2003	Yarussi et al.	356/369
6,713,753	B1	3/2004	Rovira et al.	250/225
6,934,025	B2 *	8/2005	Opsal et al.	356/369
6,982,791	B2 *	1/2006	Opsal	356/369
7,054,006	B2 *	5/2006	Wang et al.	356/369

OTHER PUBLICATIONS

R.M.A. Azzam, "PIE: Perpendicular-Incidence Ellipsometry—Application to the Determination of the Optical Properties of Uniaxial and Biaxial Absorbing Crystals," *Optics Communications*, vol. 19, No. 1, Oct. 1976, pp. 122-124.

R.M.A. Azzam, "NIRSE: Normal-Incidence Rotating-Sample Ellipsometer," *Optics Communications*, vol. 20, No. 3, Mar. 1977, pp. 405-408.

R.M.A. Azzam, "Perpendicular-incidence null ellipsometry of surfaces with arbitrary anisotropy," *Optical Engineering*, vol. 20, No. 1, Jan./Feb. 1981, pp. 58-61.

J.M. Holden et al., "Normal Incidence Spectroscopic Ellipsometry and Polarized Reflectometry for Measurement of Photoresist Critical Dimensions," *Proceedings of SPIE (Metrology, Inspection, and Process Control for Microlithography XVI)*, vol. 4689 (2002), pp. 1110-1121.

(Continued)

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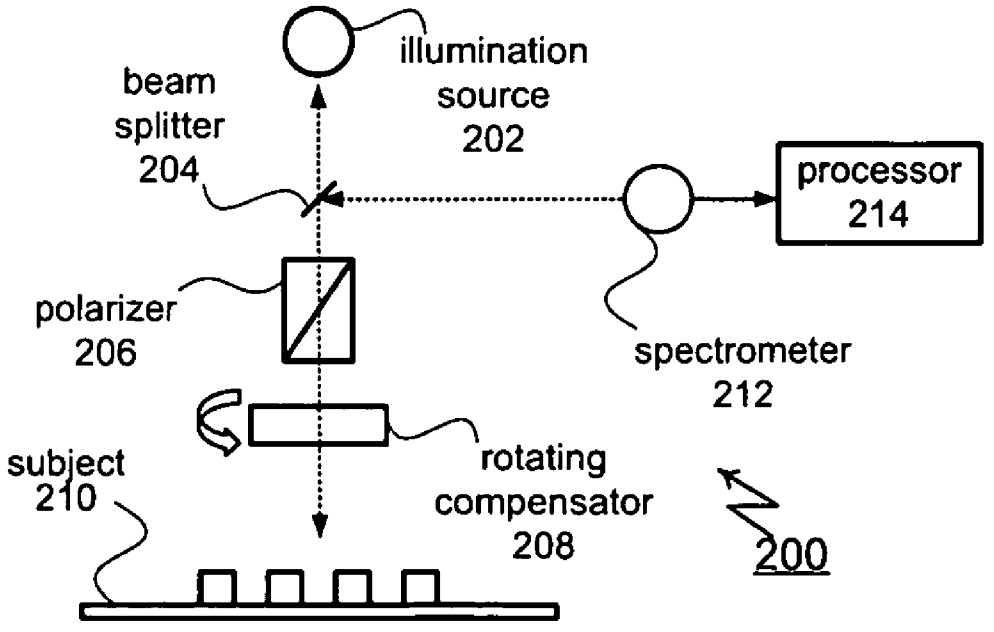
(57) **ABSTRACT**

A normal incidence rotating compensator ellipsometer includes an illumination source that produces a broadband probe beam. The probe beam is redirected by a beam splitter to be normally incident on a sample under test. Before reaching the sample, the probe beam is passed through a rotating compensator. The probe beam is reflected by the sample and passes through the rotating compensator a second time before reaching a detector. The detector converts the reflected probe beam into equivalent signals for analysis.

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